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Periodontitis prevalence in adults ≥ 65 years of age, in the USA

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Persons residing in the USA are living longer than ever before and it is projected that the proportion of adults ≥ 65 years of age will grow to comprise 21.7% of the population by 2040 (84). In 2013, the most recent year for which final data are available, there were 44.7 million adults ≥ 65 years of age, comprising one in every seven (14.1%) individuals in the entire US population (84). The proportion of adults ≥ 65 years of age is 25% (8.8 million) higher than one decade earlier, and by 2040, the proportion of such older adults is expected to increase by about 50%. The number of adults ≥ 85 years of age is expected to triple in the same period (84). Approximately 100 million (98.2 million) adults ≥ 65 years of age will be living in the USA by 2060 and by then will make up slightly more than a quarter (25.8%) of the population (20).

Not only are people living longer, many expect to live their lives in better health and with a higher quality of life than in earlier times. Oral health is an important component of an older adult's health. Poor oral health can affect overall health and well-being in various ways. For example, poor oral health conditions can lead to tooth loss, discomfort and pain, as well as difficulties in speaking, chewing and swallowing, severely decreasing the quality of life (44), and may limit food choices resulting in poor nutrition, as shown in older Japanese women (52). Furthermore, poor oral health can negatively affect a person's social and emotional health and overall quality of life (22, 40, 60, 66, 85). For example, loss of self-esteem is associated with loss of teeth (40) and with untreated disease, such as periodontitis (40, 44). Finally, periodontal disease is associated with several systemic diseases and conditions (9, 11), such as diabetes (10, 12, 45), cardiovascular diseases (50, 71, 86, 90), pulmonary diseases (55, 57, 73, 91), rheumatoid arthritis (21, 89), cognitive impairment/Alzheimer's disease (42, 48, 74, 78), as well as cancers of the oro-digestive tract (oral cavity, gastrointestinal tract, bladder, liver, kidney and pancreas) (2, 3, 6, 47, 72). Whether the "golden" years at the end of the life cycle are lived in a healthy, enjoyable and productive style depends, in part, on the oral health status. Therefore, it is important to prevent a number of oral diseases and conditions, including periodontal disease, which is one of the leading causes of the poor oral health conditions in older adults.

Older adults are keeping their teeth much longer (56). The prevalence of periodontitis has been shown to be significantly higher in 70- to 81-year-old subjects compared with those 50–59 years of age (23). In the absence of periodontal treatment, periodontitis can progress

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to loss of teeth (65). Periodontitis is a dental-plaque-bacteria-induced, and host-mediated, breakdown of soft and hard tissues surrounding the teeth (7) and is the sixth-most prevalent chronic condition in the world (53). Globally, about 11% of individuals, are affected by the severe type of periodontitis (53). As a result of its chronic and cumulative nature, periodontitis is more common in older adults, with two-thirds (68%) of persons ≥ 65 years of age being affected with chronic periodontitis in the USA (31).

Acknowledging the important role of periodontal health in overall health of adults, reduction of the prevalence of moderate or severe periodontitis among the US population aged 45 to 74 is an oral health objective designated by the Healthy People 2020 initiative is one of the indicators to track the nation's health (http://www.healthypeople.gov/2020/topics-objectives/topic/oral-health/objectives). In recognition of the emerging importance of oral health in aging adults, legislation was reauthorized by the President in 2016, to include oral health screening as part of the disease prevention and health promotion activities under the Older Americans Act (1). This is the first time since the Bill's enactment in 1965 that oral health has been specifically referenced in the Older Americans Act.

An important component of disease prevention and health promotion is having contemporary knowledge of the population characteristics and true burden of the disease in the population, especially at the state and local levels where prevention programs are implemented. Since 2009, there have been major strides in improving surveillance of periodontitis in the USA, notably in the clinical examination protocols used in the National Health and Nutrition Examination Survey (NHANES) and the use of standard case definitions for surveillance of periodontitis (34, 64). Before 2009, surveillance of periodontitis in NHANES was based on data collected using various partial-mouth periodontal examination protocols (25, 29). Since 2009, NHANES has used a full-mouth periodontal examination protocol, which optimizes surveillance measurements to permit a highly accurate classification of periodontitis (36). Also, an expert workgroup developed and suggested standard case definitions for surveillance of periodontitis which were implemented in NHANES (34, 64). Using data from the 2009–2012 NHANES and applying these suggested case definitions, we have revised the prevalence of periodontitis in US adults, reporting, for the first time, direct evidence that almost 50% of US adults ≥ 30 years of age have periodontitis (31, 32).

In the USA, oral health data on adults is nearly nonexistent at state and local levels, greatly impeding the planning, creation and implementation of public health programs focused on adult oral health. Data at state and local levels are necessary to establish the burden of oral diseases, in order to improve dental coverage and access to preventive dental measures for adults. In response to this challenge, we have developed a novel geo-spatial model for estimating the burden of periodontitis at subnational levels (i.e. at state and local levels) (37), and are also exploring the use of self-report measures in state and local surveys for estimating the burden of periodontitis (30, 33, 35).

The most recent national US data from the combined NHANES 2009–2010 and 2011–2012 cycles (subsequently referred to as "NHANES 2009–2012") was analyzed to describe the prevalence of periodontitis according to population characteristics among adults ≥ 65 years

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of age in the USA. Furthermore, we used our novel, small-area estimation model to estimate the burden and distribution of periodontitis for this age group at state and local (congressional district and county) levels in the USA.

Material and methods

NHANES is a stratified, multistage probability sample of the civilian noninstitutionalized population in the 50 states of the USA and the District of Columbia. The technical details of the survey, including sampling design, periodontal data-collection protocols and data availability may be accessed at www.cdc.gov/nchs/nhanes.htm. Additional information on the collection and quality of the oral health data is available (26). Oral health data-collection protocols for the NHANES 2009–2012 were approved by the Centers for Disease Control and Prevention National Center for Health Statistics Research Ethics Review Board (equivalent to Institutional Review Boards), and all survey participants provided written informed consent (26).

In NHANES 2009–2012, adults ≥ 30 years of age with at least one natural tooth and with no health condition requiring antibiotic prophylaxis before periodontal probing were eligible for the periodontal examination. A total of 9,402 adults were ≥ 30 years of age and, of those, 1,983 were ≥ 65 years of age. Data from 472 of the latter were excluded from our analyses either because they did not undergo the periodontal health assessment because they were edentulous (edentate, having no teeth) or had medical exclusion reasons or incomplete oral examinations, or because our analyses were further restricted to respondents with no missing values for all covariates. Hence, our analyses are based on complete data from the remaining 1,511 older adult participants, representing a weighted population of approximately 23.8 million civilian noninstitutionalized American adults ≥ 65 years of age (31).

Periodontal examinations were conducted in a mobile examination center. Gingival recession (i.e., the distance between the free gingival margin and the cemento–enamel junction), followed by periodontal probing depth (i.e., the distance from the free gingival margin to the bottom of the sulcus or the periodontal pocket) were measured at six sites around each tooth (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual) for all teeth, excluding third molars. To obtain measurements, a periodontal probe (Hu-Friedy PCP 2™) with 2-, 4-, 6-, 8-, 10-, and 12-mm gradations was positioned parallel to the long axis of the tooth at each site. Each measurement was rounded to the lower whole millimeter. Data were recorded directly into an NHANES oral health data-management program that instantly calculated the clinical attachment loss as periodontal probing depth minus gingival recession.

The training and calibration of the two examiners for the 2009–2010 cycle is described in detail elsewhere (26). Briefly, examiners were trained and calibrated before commencing the field work, as well as being recalibrated by duplicate examinations of 25–30 participants, two to three times a year, during the visits by the gold standard examiner to the mobile examination centers. Inter-rater reliability statistics were calculated for each of the periodontal measures, namely for one site with ≥ 4 mm clinical attachment loss, one with ≥ 6 mm clinical attachment loss, ≥ 5 mm periodontal probing depth, and one with ≥ 7 mm

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periodontal probing depth, respectively. Kappa varied between 0.56 and 0.71, with 78–93% agreement. Periodontitis cases were defined according to the Centers for Disease Control and Prevention/American Academy of Periodontology case definitions suggested for surveillance of periodontitis (34, 64). The kappa statistics were 0.54 and 0.56 with 77% and 82% agreement for total (mild or moderate or severe) periodontitis when applied to the full mouth (except third molars), for measurements made at six sites per tooth; 0.70 and 0.71 with 86% and 87% agreement for moderate plus severe periodontitis, and 0.36 and 0.41 with 90% and 93% agreement for mild periodontitis. The reliability was comparable between the examiners, whereas agreement was considered substantial for one examiner and moderate for the other. Importantly, both examiners' consistency increased with increasing disease severity (26).

Severe periodontitis was defined as having two or more interproximal sites with ≥ 6 mm clinical attachment loss (not on the same tooth) AND one or more interproximal site(s) with ≥ 5 mm periodontal probing depth. Second, nonsevere periodontitis combined two levels of disease, namely moderate periodontitis and mild periodontitis. Moderate periodontitis was defined as having two or more interproximal sites with ≥ 4 mm clinical clinical attachment loss (not on the same tooth) OR two or more interproximal sites with periodontal probing depth ≥ 5 mm, but not on the same tooth; and mild periodontitis was defined as having two or more interproximal sites with ≥ 3 mm clinical attachment loss and two or more interproximal sites with ≥ 4 mm periodontal probing depth (not on the same tooth) or one site with ≥ 5 mm periodontal probing depth. Both categories are not truly ordinal as the label suggests because many of the "moderate" cases had insufficient probing depth to be categorized as "mild" and therefore we combined them under the label "nonsevere" periodontitis (35, 38). Finally, total periodontitis was defined as the presence of severe or non severe periodontitis, that is, any mild, moderate or severe periodontitis, and is reported as "periodontitis."

Consistent with previous studies, we selected for our analyses, sociodemographic, behavioral and comorbid risk indicators previously reported for periodontitis (13–15, 24, 27, 28, 43). The variables age (categorized as 65–74 and 75+ years) and sex (male, female), as collected by NHANES, were included in the analyses. Race/ethnicity was analyzed in four groups: non-Hispanic White people, non-Hispanic Black people and Hispanic people (i.e. anyone who self-identifies as "Hispanic," a combination of Mexican Americans and other Hispanic people, of which the majority self-identify as Mexican Americans), and other race/ethnicity (including multiracial). Education was classified as: less than high school; high school graduate or General Education Development high school equivalency test; and greater than high school. Poverty status categories were based on the percentage of poverty relative to the Federal Poverty Levels derived from family income, household size, number of children in the family for families with two or fewer adults and on the ages of the adults in the household. The poverty level was based on definitions originally developed by the Social Security Administration (39). Families or individuals with income below their appropriate thresholds were classified as being below the Federal Poverty Level. These thresholds are updated annually by the US Census Bureau (http://aspe.hhs.gov/poverty/11poverty.shtml).

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Smoking status was constructed from the responses to two questions: (i) Have you smoked at least 100 cigarettes in your life?; and (ii) Do you now smoke cigarettes? Respondents who reported smoking every day or some days and had smoked at least 100 cigarettes were categorized as current smokers; respondents who reported currently not smoking but having smoked more than 100 cigarettes in the past were categorized as former smokers; and respondents who reported not having smoked at least 100 cigarettes were categorized as nonsmokers. Diabetes status was defined based on self-reported response to the question "Have you been told by your doctor or a health care professional that you have diabetes?" Body mass index (BMI) was used to determine levels of weight status. An individual with a BMI of < 18.5 kg/m^2 was considered underweight, with a body mass index of 18.5–24.9 kg/m^2 as being of normal or healthy weight, with a body mass index of 25.0–29.9 kg/m^2 as being overweight and with a body mass index of ≥ 30.0 kg/m^2 as obese (19, 44). Dental visits were based on the self-report response to the question "About how long has it been since you last visited a dentist?" The response to this question included all types of dentists, such as orthodontists and oral surgeons, and all other dental specialists, as well as dental hygienists. Similarly, use of dental floss was based on a self-report response to the question "Aside from brushing {your/his/her} teeth with a toothbrush, in the last 7 days, how many days did {you/SP} use dental floss or any other device to clean between {your/his/her} teeth?"

Descriptive statistics were calculated by category or severity of periodontitis [i.e. severe and nonsevere (mild and moderate) periodontitis; and total periodontitis (the sum of severe and nonsevere periodontitis)]. All analyses of NHANES were conducted using the SAS-callable format of the SUDAAN program and using NHANES mobile examination center examination weights to account for the complex survey sampling design.

We used a multilevel regression and post-stratification model to determine state and local area estimates of periodontitis in the USA. Details of this method are reported elsewhere (37, 92). Briefly, data from four sources (NHANES, Behavioral Risk Factor Surveillance System, US Census and American Community Survey) were used in our multilevel regression. First, NHANES 2009–2012 data were used to construct regression models best representing the associations between the percentages of periodontitis and age, sex, race or ethnicity, poverty, and a major modifiable risk factor: smoking (81). Using the best model, we then constructed population counts for periodontitis for each of these variables at the US Census block level, which is the smallest US Census unit. Because smoking and poverty statuses are not collected by the US Census, we used both Behavioral Risk Factor Surveillance System data and the US Census 2010 Summary File 1 population data to estimate population counts by smoking status for the selected demographic characteristics (age, gender, race or ethnicity) at the census block level. Then, we further assigned poverty status to these population counts according to smoking status via bootstrapping using the American Community Survey 2008–2012 poverty estimates at the census block level. Finally, using the estimated population counts having demographics, smoking and poverty statuses, we then applied the fitted models from NHANES to generate the prevalence estimates of periodontitis at the census block level. These estimates were then aggregates upward to other larger geographic levels of interest, such as county, congressional districts and states.

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Results

Among the 1,983 participants, ≥ 65 years of age, in the NHANES 2009–2012, fewer than one (19%) in five was edentulous: one-seventh (13.7%) of the 65- to 74-year-old subjects were edentulous compared with one-quarter (24.1%) of those ≥ 75 years of age. Periodontal and all co-variable data were complete for 1,511 dentate individuals, and Table 1 displays their population-weighted characteristics.

The mean age of the study participants was 72.5 years, and 7.1% were current smokers, with a significantly higher prevalence of smokers in the 65–74 years age group than in the 75+ years age group. Almost 8% of the participants had an income of < 100% of the Federal Poverty Level. Regarding body mass index, approximately one-third of all participants in each group were distributed in the categories < 25, 25–29.9 and ≥ 30 kg/m^2, and one-fifth of participants had diabetes. Over 70% reported to have used dental floss the past week, namely three-quarters of the younger and two-thirds of the older age group.

The measurements for probed sites are reported in Table 2. Sites with ≥ 3 mm clinical attachment loss were present in nearly all older adults (96.4%), and almost two-thirds (62.3%) of adults had one or more sites with clinical attachment loss of ≥ 5 mm. On average, almost 30% of sites had clinical attachment loss of ≥ 3 mm, with toward 10% having clinical attachment loss of ≥ 5 mm. Slightly more than half (52.6%) of teeth were affected by clinical attachment loss of ≥ 3 mm and one in five had clinical attachment loss of ≥ 5 mm. The mean clinical attachment loss and periodontal probing depth were 1.7 and 1.6 mm, respectively. Almost half of the older adults had at least one site with periodontal probing depth ≥ 4 mm and over 10% had one or more sites with periodontal probing depth ≥ 6 mm; about 10% of the teeth had probing depths of ≥ 4 mm, with about 1.6% of the teeth affected by periodontal probing depth of ≥ 6 mm.

Overall, 19.8% of the older adult male participants and 29.5% of the female participants were free of periodontitis, with significantly more female participants in both the 65–74 and the 75+ years age groups having no periodontitis, whereas about two-thirds (64.1%) of both sexes had nonsevere periodontitis (Table 3). Almost one in six men compared with one in 16 women had severe periodontitis, and in the 65–74 years age group the prevalence of severe periodontitis was three times higher in male participants than in female participants. Whereas the prevalence of nonsevere periodontitis seemed to increase with age, the prevalence of severe periodontitis did not. However, the proportion of periodontitis-free older adults decreased according to age group in both sexes as the prevalence of nonsevere periodontitis increased.

Table 4 displays the distribution of severe and nonsevere periodontitis among older adults. Overall, nonsevere periodontitis was more prevalent in the older subgroup (≥ 75 years) and severe periodontitis was significantly more prevalent in male participants. The prevalence of severe periodontitis was highest among current smokers, and the prevalence of nonsevere periodontitis did not differ according to smoking status. The prevalence of severe periodontitis was lowest in the highest income category; and between 60% and 70% of all income groups had nonsevere periodontitis and between 70% and 80% had (total)

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periodontitis. The prevalence of any type of periodontitis remained the same across BMI categories. The prevalence of severe periodontitis was not different when participants were grouped by diabetes status, but nonsevere periodontitis was slightly higher among participants in the older age group. Severe periodontitis was highest among those who reported not using dental floss in the past 7 days and was highest among those reporting to have had a dental visit in the previous 6 months, with three-quarters of such subjects affected by periodontitis.

A summary of the estimated prevalence of total periodontitis among adults ≥ 65 years of age, stratified according to state and administrative geographic area, is presented in Table 5. Overall, the prevalence of total periodontitis ranged from 62.1% to 74.2% across all states, with an average of 66.2%. The prevalence of total periodontitis in the congressional districts was similar to that for states and had a similar mean value (67.1%), but the maximum was higher, at 83.3% (Table 5). The prevalence of total periodontitis in US counties ranged from 59.4% to 84.5%, whereas the prevalence in the various US Census tracts showed a slightly wider range, from 47.8% to 93.4%. Regardless of the administrative unit, periodontitis was present in two-thirds of participants, on average (range of mean values: 66.2–68.0%), with the median prevalence ranging from 65.6% to 65.9%.

With respect to severe periodontitis, the prevalence in the US varied from 9.5% to 16.3% and the prevalence in the congressional districts ranged from 9.0% to 21.4%. The prevalence of periodontitis in the counties was as low as 8.5% and as high as 24.0%, whereas the prevalence in the different Census tracts showed a much larger range, from 4.2% to almost 10-fold that magnitude (41.8%). Overall, the mean prevalence of severe periodontitis was around 12% among the older adult US inhabitants (≥ 65 years of age), regardless of the administrative or geographical unit, with a spread from 11.8% to 12.8% and with the median prevalence between 11.4% and 11.8%.

The prevalence of total periodontitis and severe periodontitis in all 50 US States and the District of Columbia, as well as in each of the US States and in the District of Columbia, is presented in Table 6 and illustrated in Fig. 1, respectively. The lowest prevalences of total periodontitis were found in Utah (62.1%) and New Hampshire (62.6%) and the highest were found in New Mexico, Hawaii and the District of Columbia, each with a prevalence of more than 70%. The difference between the States with the highest (74.2% in District of Columbia) and lowest (62.1% in Utah) prevalence of total periodontitis was 12.1%, and the prevalence of total periodontitis ranged from 65% to 69% in two-thirds of States. In two states (Utah and New Hampshire), the prevalence of severe periodontitis was below 10%, and six states had a prevalence of severe periodontitis of more than 13%, with maximally one in six older adults in the District of Columbia (16.3%) having severe periodontitis.

Figure 2 shows the prevalence of severe periodontitis among older adults in the 50 US and the District of Columbia categorized into prevalence quintiles, with a darker color signifying higher prevalence. The states with the two highest prevalence quintiles of severe periodontitis (12.2–16.3%) are mostly located in the South and South-Western area of the USA, with Nevada (13.0%) being the most northern state in the highest quintile, and the state of New York being the only northern state in the second highest category of severe

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periodontitis with a prevalence of 12.4% (Table 6). The following 14 states, which include the six most north-eastern states, are in the quintile with the lowest prevalence quintile (≤ 10.9%) of severe periodontitis: Connecticut, Iowa, Maine, Massachusetts, Minnesota, Nebraska, New Hampshire, North Dakota, Rhode Island, South Dakota, Utah, Vermont, Wisconsin, and Wyoming (Table 6, Fig. 2).

The congressional districts with periodontitis prevalence (≥ 70.7%) in the highest quintile are located in Hawaii and the southern part of the USA, as well as in large urban areas near port cities of the Mississippi River, the Great Lakes and the Atlantic Ocean (Fig. 3). Conversely, the lowest prevalence of periodontitis (61.1–64.0%) is found predominantly in the northern and midwestern districts.

The prevalence of periodontitis in each of the 3,143 US counties is illustrated in Fig. 4, with the prevalence increasing with darker color. Counties with a lower prevalence of periodontitis are mostly located in the northern Midwest, central, and eastern parts of the USA, whereas the counties with the highest prevalence of periodontitis tend to be found in the southern states, Alaska and Hawaii.

Discussion

This report describes, for the first time, a more detailed picture of periodontitis among older adults, by sociodemographic factors, health behavior and US sub-national geographical distribution. Overall, periodontitis is highly prevalent among US adults ≥ 65 years of age, of whom about two-thirds of the dentate are estimated, by our modeling, to be affected in any state, congressional district or county, with about one-tenth being affected with severe periodontitis.

All earlier NHANES protocols used random partial-mouth periodontal examinations at two or three sites of all teeth except third molars and thereby probed maximally 28 ($7 \times 2 \times 2$) or 42 ($7 \times 2 \times 3$) sites compared with the 168 (28×6) sites probed in the full-mouth protocol used in the 2009–2012 cycles of NHANES. This full-mouth protocol optimizes measurements to obtain a more accurate classification of periodontitis. Consequently, no direct comparisons – or trend estimates – can be made using results from earlier NHANES cycles that report a much lower (two to three times less) prevalence of periodontitis as a result of the protocols applied and the highly site-specific nature of periodontitis, both of which will lead to gross underestimation of the true prevalence of periodontitis (36).

Using the same NHANES 2009–2012 data and the Centers for Disease Control and Prevention/ American Academy of Periodontology periodontitis case definitions, Garcia and colleagues calculated that older adults, 65+ years of age, had a significant, seven-fold higher risk (adjusted odds ratio = 7.03; 95% confidence interval: 5.28–9.37) for having periodontitis than the youngest age group (30–34 years) examined (41). However, all our measures (except for the mean) of clinical attachment loss were significantly higher in the 75+ years age group compared with the 65–74 years age group, whereas all measures of periodontal probing depth were higher in the 65–74 years age group, although only the proportion of sites with periodontal probing depths of 4 and 6 mm, respectively, were

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statistically significantly higher. This may be because older adults in the 75+ years age group had diseased teeth extracted, as they, on average, had fewer teeth compared with older adults in the 65–74 years age group.

Periodontitis is most prevalent among current smokers with the vast majority (92.6%) being affected. This is consistent with previous studies among the general population (4, 81) as well as with the 2014 Surgeon General's Report on the Health Consequences of Smoking, all of which may suggest a causal relationship between smoking and periodontitis (82). Thirty percent of current smokers have severe periodontitis. About 12% of participants in the younger age group category (65–74 years) were current smokers, but this prevalence was significantly lower (4.5%) in participants 75+ years of age. The likelihood of having periodontitis decreased significantly among former smokers and this group did not differ significantly from that of nonsmokers. The finding that periodontitis prevalence is highest among current smokers is also consistent with our results obtained from analyzing the NHANES 2009–2012 data for all age groups examined, which showed that severe periodontitis was present in 18.9% of current smokers but only in 5.5% of nonsmokers (31). This finding supports the potential benefits of smoking cessation in older adults in preventing and controlling periodontitis. Moreover, smoking-cessation intervention in dental offices has been shown to be beneficial in recent systematic reviews, although these did not focus specifically on the oldest age groups (18, 67).

Neither the prevalence of severe nor of nonsevere periodontitis in older adults differed significantly according to weight or diabetes status, with a prevalence of severe periodontitis of 10–11% and of nonsevere periodontitis of around 66% in all BMI weight categories and in both those with and without diabetes. The lack of association between periodontitis and weight in older adults has also been seen among nonsmoking Finnish older participants, in whom there was no difference in periodontitis prevalence by body mass index category (63).

Our study used self-reported diabetes status (Yes/No). Garcia and colleagues also found no association between periodontitis prevalence and self-reported diabetes (41). These authors found that levels of glycated hemoglobin were indeed significantly associated with the presence of periodontitis and they calculated an increased risk of 18% for having periodontitis for each percentage point increase in glycated hemoglobin ($P < 0.001$) for the entire study population 30+ years of age (41). This suggests that diabetes control is a key factor in determining the relationship to periodontal diseases. An additional factor helping to explain our finding of little or no association of periodontal disease with diabetes comes from the fact that more than one-quarter (27.8%) of US individuals with diabetes are undiagnosed (17) and therefore will not report having diabetes.

Exacerbating the situation for US older adults ≥ 65 years of age is that a considerable proportion of this population segment lives in poverty, with over two-thirds (69%) having incomes of < 400% of the Federal Poverty Level; lower-income older adults had increased prevalence of periodontitis, with up to 17.7% of the poorest being affected by severe periodontitis and 80% by any periodontitis type. Income and education are also associated with dental visits among older adults (58). The highest prevalence of severe periodontitis occurred among those reporting having a dental visit in the previous 6 months, which might

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seem counterintuitive at first glance. However, the recent dental visits might be to seek care for periodontitis-related or other oral health issues – such as pain, discomfort or mastication problems as a result of mobile teeth; foul taste or malodor owing to pus flow from periapical abscesses; or symptomatic dental caries – all part of having a poor oral health status. Information regarding the reason for the last dental visit is not collected, so it cannot be determined whether the recent visits were because of symptoms and extractions, for routine check-ups or for completing restorative treatment in a series of visits. Another explanation could be that it is difficult for older adults to attain and maintain good oral health, as concluded in a study of older Swedish subjects: “Despite frequent dental visits, overall oral health in the oldest age cohort was poor” (68). This is further illustrated in another Scandinavian country, where dental visits were only weakly associated with income: just 2.4% of Danish older adults between 65 and 74 years of age had a healthy periodontium; two-thirds had pockets of 4–5 mm; one in five had pockets of ≥ 6 mm pockets and almost all (93.1%) had bleeding on probing (54). It is noteworthy that 88.3% of this older adult Danish population had regular dental visits in their adulthood.

Severe periodontitis was more prevalent among dentate older adults who reported not having used dental floss in the past 7 days (13.8%) compared with those who did use floss (9.7%), which would be expected if flossing was efficacious. Nonetheless, about two-thirds of the older adults had nonsevere periodontitis, and about three-quarters had any type of periodontitis, regardless of floss use. Use of dental floss requires a high level of knowledge and skills that need to be exerted simultaneously, such as coordination, dexterity, accuracy, flexibility, and preferably good eyesight, attributes which are absent or reduced in many older individuals. The Lifestyle Change plus Dental Care program resulted in improved knowledge, attitude and practice toward oral health and diabetes mellitus among older adults with type 2 diabetes, including higher use of dental floss (69). However, in the absence of such a program, ineffective use of dental floss could explain the failure to keep the dentition periodontitis-free in this US population of older adults with low dental care attendance. There is only weak scientific evidence for the efficacy of dental floss in plaque control and managing gingivitis (5, 70), the condition that preceded periodontitis.

There is no dental insurance in the federal Medicare program and hence most older adults are generally responsible for the full cost of their dental care unless they have dental insurance(http://www.ehealthmedicare.com/about-medicare/dental/) and most Medicaid state programs have minimum requirements for adult dental coverage (http://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Benefits/Dental-Care.html), meaning that most of the costs of dental care need to be met by the patients. Several states have decided to expand Medicaid programs to offer comprehensive oral health coverage for adults: as of September 2014, a total of 28 states had decided to move forward with these plans (62). Nonetheless, it is unclear exactly how many states currently have funded and implemented these programs. In any case, allocation of funds for such programs can fluctuate depending on the economy and politics of each state, and such programs risk being discontinued when the state budgets are reduced (62). Approximately 70% of Americans over the age of 65 years do not have dental insurance (58–60). Despite progress in medical care coverage with the Affordable Care Act (76, 86), dental coverage is not generally included. Half of this population reported to not having seen a dentist for any

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reason in the last year attests to barriers to obtaining dental care in this older cohort. A similar situation exists in Canada, according to a report stating that only one-third (36.2%) of dentate, independently living persons ≥ 65 years of age had seen a dentist in the last 6 months (16).

Retention of about 20 natural teeth could represent a functional dentition (46), provided that the teeth are in reasonably good health and are well positioned in the maxilla and mandible to facilitate mastication (61). However, with almost 20% of teeth having clinical attachment loss of ≥ 5 mm, some could be mobile and thus have decreased utility and possibly cause pain while chewing. However, it is encouraging that the number of natural teeth retained has dramatically increased among US older adults during the last four decades (56). Even during the relatively short period from 1988–1994 to 1999–2004, the mean number of teeth among dentate persons of at least 65 years of age increased from 17.9 to 18.9 (28), which seems in line with the current average of 21.1 teeth. It can therefore be concluded that the number of retained teeth has increased by an average of 3.2 teeth between NHANES 1988–1994 (17.9 teeth) and NHANES 2009–2012 (21.1 teeth), namely during only the last two decades. The number of teeth in younger (65–74 years) vs. older (≥ 75 years) age categories were 19.1 vs. 16.4 in 1988–1994, 19.3 vs. 18.4 in 1999–2004 and 22.0 vs. 19.7 in 2009–2012.

About 19% of US adults ≥ 65 years of age are edentulous. The prevalence of edentulism has decreased drastically over time in the USA and in many other industrialized countries. Between NHANES 1988–1994 and NHANES 1999–2004, the prevalence of edentulism in persons 65+ years of age decreased from one-third (33.9%) to near one-quarter (27.3%) (28), and is now further reduced to about 19% (http://www.cdc.gov/nchs/data/databriefs/db197.htm). Edentulism is less prevalent in the younger (65–74 years) age group than in the older (≥ 75 years) age group, 28.6% vs. 40.3% in 1988–1994, 22.6% vs. 28.7% in 1999–2002, and 13.7% vs. 24.1% in 2009–2012 respectively (75). The latter figures are calculated from the same 2009–2012 NHANES data by Slade et al. (75) who defined edentulism as missing all 32 teeth. Compared with the prevalence of edentulism in 1957–1958 in the two age groups (55.4% for participants 65–74 years of age and 67.3% for participants ≥ 75 years of age), the relative declines were 75% (41.7% absolute decline) for participants 65–75 years of age and 64% (43.2% absolute decline) in participants ≥ 75 years of age (75). The prevalence of edentulism among the 65- to 74-year-old subjects (13.7%) is significantly lower than the goal of 21.4% set forth in the Healthy People 2020 report and is predicted to continue to decrease (75). A consistent decrease in self-reported edentulism was also found by the National Health Interview Survey when comparing each year in five different race/ethnic groups from 1999 to 2008, with the prevalence in Caucasians decreasing from 21.5% in 1999 to 16.9% in 2008, but from 24.6% to 19.4% in African-Americans and from 33.2% to 24.0% in Native Americans (87).

The prevalence of edentulism in older US adults appears to be lower than in Germany but higher than in Japan (49). Comparison of 70-year old Japanese subjects with two cohorts of 65- to 74-year-old German subjects identified significantly higher levels of periodontitis among the German subjects, who also had fewer teeth and more edentulism (7.5% in Japanese subjects vs. 33.5% and 22.9%, respectively in the two German cohorts), and the authors concluded that the known risk factors were not able to explain these differences (49).

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Therefore, there may be differences in the cultural or environmental conditions, or possibly variations in dental-practice patterns or in access to care. Even though edentulism has decreased in other countries, its prevalence is still relatively low among US older adults compared with those in other countries. For instance, almost three-quarters (72.7%) of 1,751 older adults in Manitoba, Canada, were edentulous in 1991–1992 (16). In Finland, another developed country, the prevalence of edentulism among those ≥ 65 years of age was 44% (38% in men and 48% in women) in a nationwide survey conducted in 2000 (79). Of the 65- to 74-year-old subjects, 36% had no teeth compared with 56% of those 75+ years of age. Dentate Finnish older adults, ≥ 65 years of age, had, on average, 15.4 teeth (in both sexes), with 16.3 teeth in the those 65–74 years of age and 13.4 teeth in those 75+ years of age (86). Among 111,123 Japanese adults 65+ years of age in 2010–2012, 13.8% of both men and women were edentulous (51). New Zealand is historically the industrialized country with the highest rates of edentulism in the world (77), although the rate of edentulism among 65- to 74-year-old subjects has decreased drastically, namely from 90% in 1951 to 72.3% in 1976, to 58.6% in 1988 and to 29.6% in 2009 (77). The 2009 estimate is within the 95% confidence interval for the predictions made in 1997 on the basis of the 1976 and 1988 rates (78), which shows that it is possible to make valid and realistic estimates for edentulism rates. Taken into account was that the first baby boomers reached 65 years of age during 2011, an important factor for all health-care planners, insurance companies, policy makers and any other entities affected by the increasing proportion of the older population (77). The death of the older generations and the growing baby boomer population were also factors in the projections by Slade et al. (75).

Limitations

This study has the limitations inherent in cross-sectional studies, such as the inability to demonstrate any causality in links between potential risk factors and periodontitis prevalence. The study design did not include groups of older adults who do not live in the general community, so the results do not include persons in institutions, such as nursing homes, hospitals, hospices or prisons.

This report does not address other health aspects of teeth, such as caries, or the distribution within the oral cavity of teeth with regard to the existence of functional units with opposing teeth positioned for mastication. Oral health-related quality of life depends on both the number and the position of the teeth (8). Disparities are known to exist among more subgroups than could be included in this report (14, 27, 80, 88). Finally, because the periodontitis case definitions used require two teeth for the person to be allocated to a periodontitis category, only persons with at least two teeth were included in the periodontitis case categories in the final analyses, whereas an individual classified as having no periodontitis theoretically could have one tooth present that is affected by periodontal disease. However, we believe that this scenario is rare. In addition, we note a limitation of our model estimates for periodontitis at the state and local levels. Although the performance of our model has been validated against clinically determined periodontitis at the national level (using NHANES), similar validations against state and local levels have not been done because clinical estimates at these levels are currently unavailable.

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Strengths

The most important strengths of this study are the large, nationally representative sample and the periodontal examination protocol applied, which, for the first time in the NHANES series of studies, includes probing at six sites around all teeth, except for third molars. Also, periodontitis cases were defined following standard case definitions for surveillance of periodontitis. In combination, these two factors make it possible, for the first time, to estimate the actual prevalence of the total periodontitis, as well as the different subcategories of periodontitis, in the oldest segment of the US population. Furthermore, we were able to apply a novel geo-spatial model to estimate the burden and geographic distribution of periodontitis at sub-national levels in the US. These estimates should help to predict places with higher/lower prevalences of periodontitis for health planning and decision making, but not for determining accuracy of the existing local level intervention.

Future challenges

With people living longer and keeping their natural teeth for much longer than in the past, and possibly being affected with several comorbidities and poverty, new challenges for the delivery of dental care arise. Dental professionals need to be knowledgeable regarding how to treat the medically complex patient whose dental care needs can be equally challenging. Considering that periodontal disease is chronic and irreversible and therefore cumulative, older persons are more likely than younger adults to have to endure the consequences of their oral health experiences from earlier years, such as the loss of tooth support and loss of teeth, and hence need costly replacement of teeth. Also, older adults presenting with multiple chronic diseases and who smoke are likely to use medications that increase xerostomia (e.g., inhaled beta2-antagonists) and alter the gingival microflora (e.g., inhaled steroids).

Additionally, self-management of oral health problems can be complicated by decreased ability to care for one's oral health. In 2009, about 41% of those ≥ 65 years of age who enrolled in Medicare reported a functional limitation (38). Specifically, about 25% reported limitations in activities of daily living, with at least one of those limitations defined as difficulty in performing (or the inability to perform for a health reason) one or more of the following tasks: bathing, dressing, eating, getting in/out of chairs, walking or using the toilet; and another 4% were living in a longterm care facility (38). In 2014, limitations in activities of daily living were present in about 4% of 65- to 74-year-old subjects, but affected almost one in five persons of 75+ years of age (http://www.cdc.gov/mmwr/volumes/65/wr/mm6501a6.htm). Such health-related limitations could be problematic in both home self-care and in the access and delivery of professional dental care. Cigarette smoking, specifically current smoking, remains an important modifiable risk for all levels of periodontitis severity in older adults. Furthermore, older adults have multiple chronic conditions that may affect their self-management regimen and their professional dental treatment that requires the provider to have good medical knowledge and skills to manage complex patients. It should be mentioned that periodontitis adversely affects some of these systemic diseases, such as contributing to hyperglycemia and possibly to diabetes complications (12).

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In addition to the practical, functional, physical, social and health-related issues, our seniors are also among the most disadvantaged groups with regard to low health literacy, defined by Healthy People 2010 as the ability/capacity to "obtain, process, and understand basic health information and services needed to make appropriate health decisions" (83). Nationwide research by the US Department of Education, among over 19,000 adults, demonstrated that only 12% scored "Proficient" in health literacy, leaving nearly nine out of 10 English-speaking adults affected by limited health literacy; this situation is even worse among seniors, minorities and non-English-speaking individuals. Health-care providers need to be aware of the very low level of health literacy in our senior population and learn to adjust their treatment and information transfer accordingly.

Finally, more information is needed on the oral health of aging adults in the USA. Currently, efforts are being made to enhance surveillance of periodontitis at state and local levels. This includes developing new, affordable and valid measures, such as the use of self-report measures when collected from existing state and local surveys (33, 35).

Conclusion

Our findings could assist policy makers and other stakeholders in planning public health programs to address this very prevalent health issue in older adults. Periodontitis has the potential to impact the oral health and general well-being of older adults. This study demonstrates clearly that periodontitis is highly prevalent among older adults in the USA. Preventive dental care made available to older adults will improve their oral health status, and it may potentially improve their quality of life. A patient-centered medical/dental interprofessional team could contribute to improving oral health, as well as general health. In addition, dental visits can present an opportunity for tobacco cessation-counseling which may improve overall health, especially in older adults.

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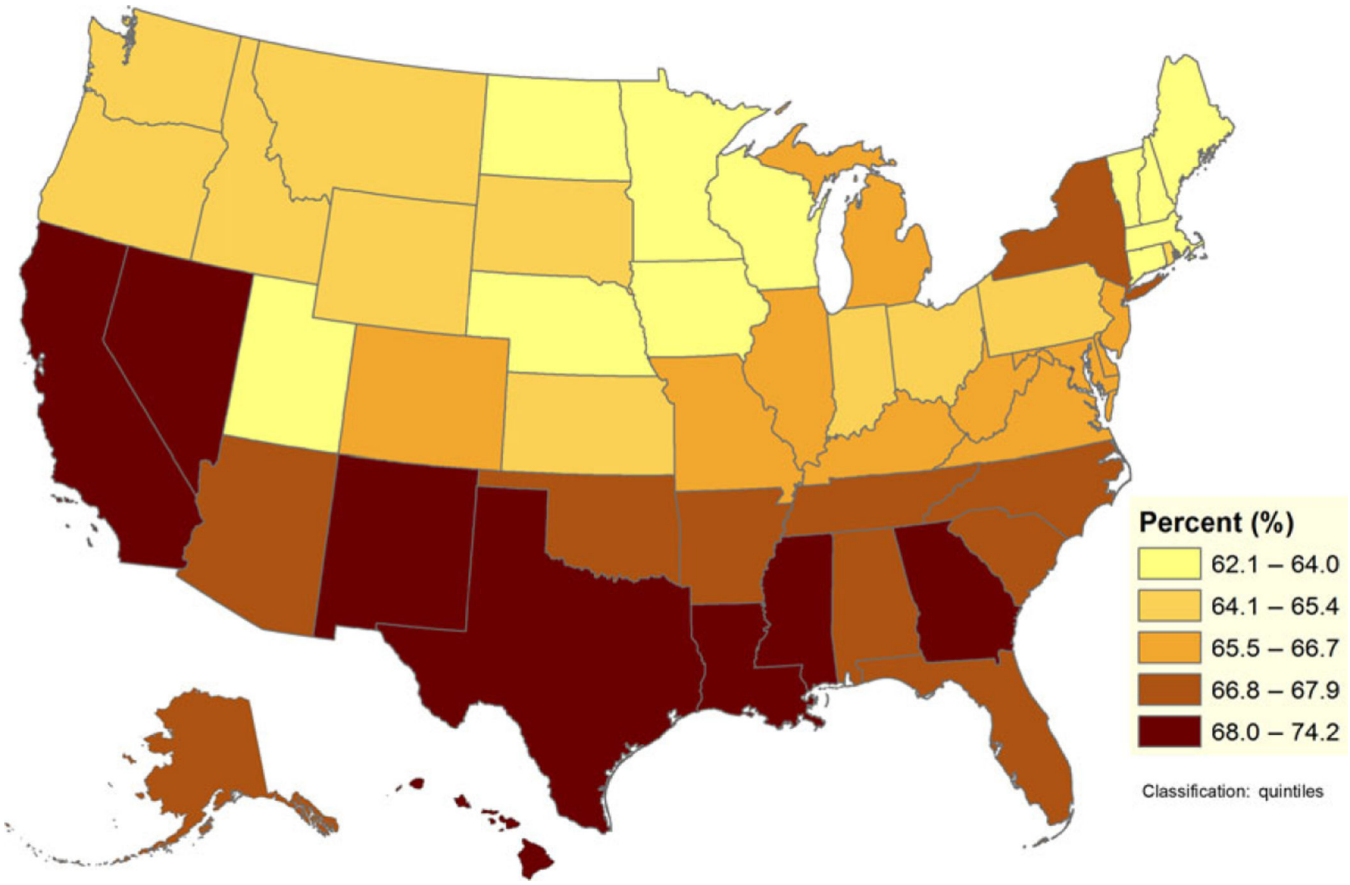

Fig. 1.

Model estimated prevalence of periodontitis in adults, ≥ 65 years of age, in each US state, 2009–2012. Data sources: CDC NHANES 2009–2012, Behavioral Risk Factor Surveillance System 2012, Census 2010, ACS 2007–2011.

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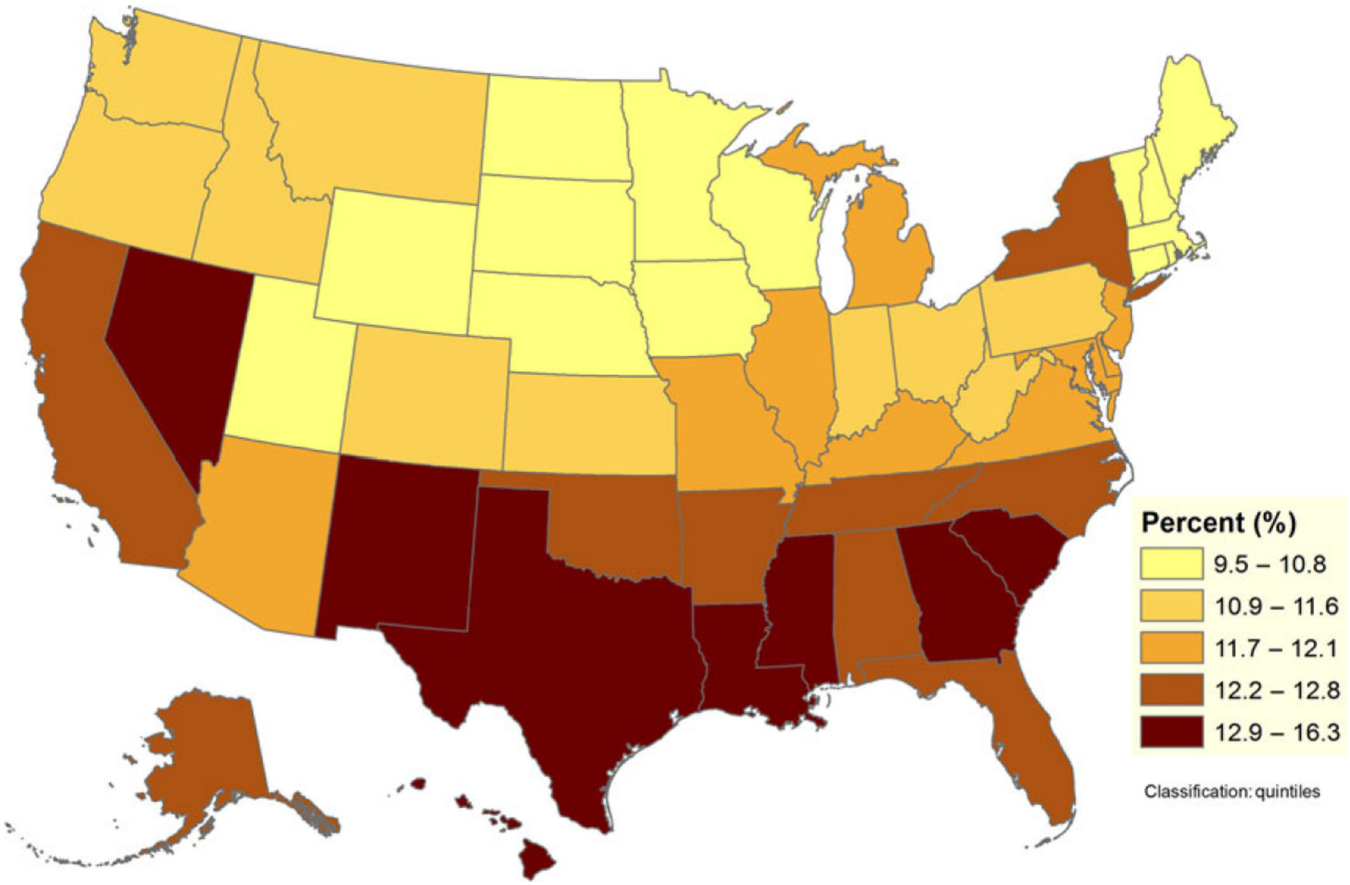

Fig. 2.

Model estimated prevalence of severe periodontitis in adults, ≥ 65 years of age, in each US state, 2009–2012. Data sources: CDC NHANES 2009–2012, Behavioral Risk Factor Surveillance System 2012, Census 2010, ACS 2007–2011.

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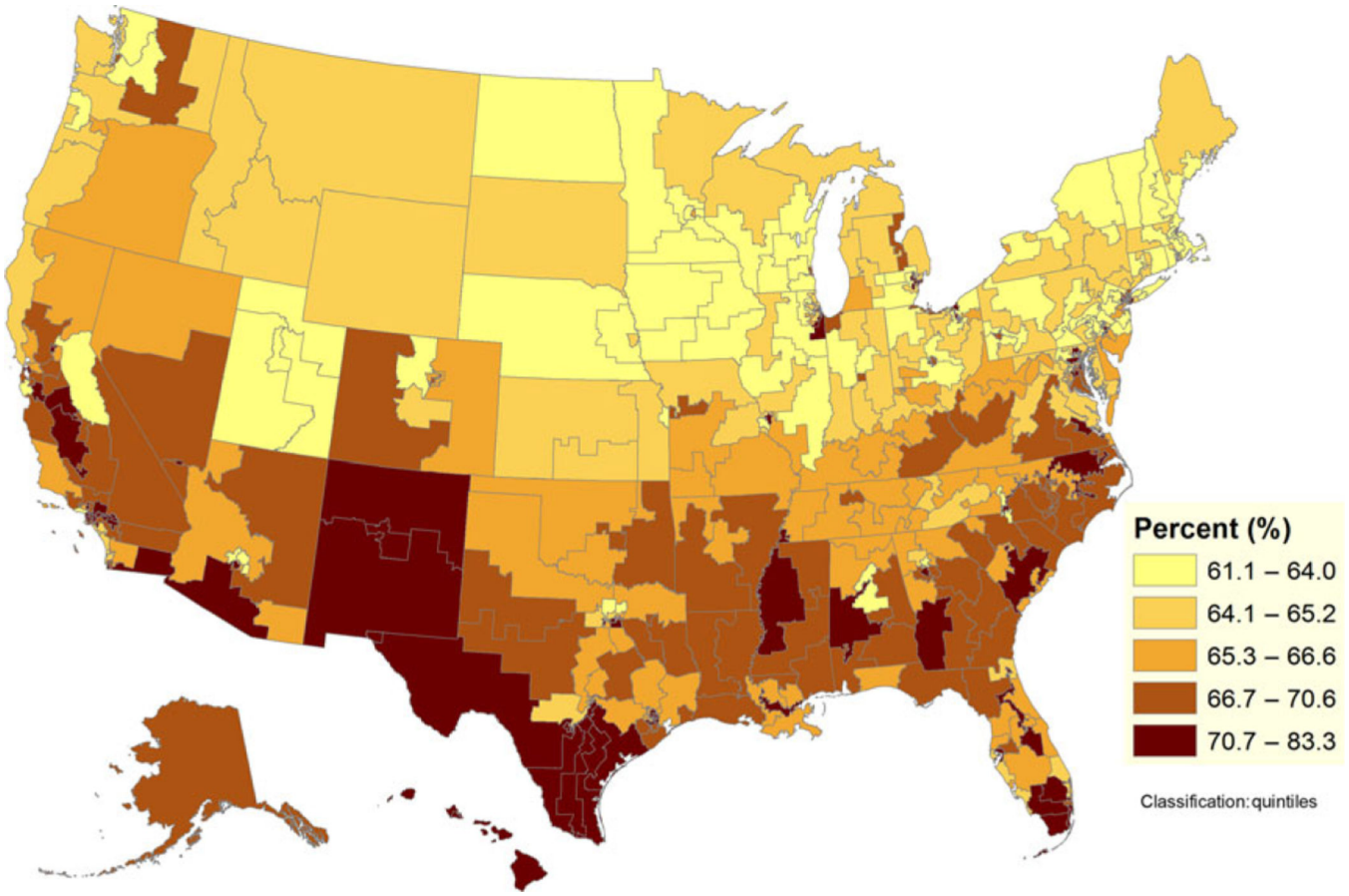

Fig. 3.

Model estimated prevalence of periodontitis in adults, ≥ 65 years of age, in US Congressional Districts, 2009–2012. Data sources: CDC NHANES 2009–2012, Behavioral Risk Factor Surveillance System 2012, Census 2010, ACS 2007–2011.

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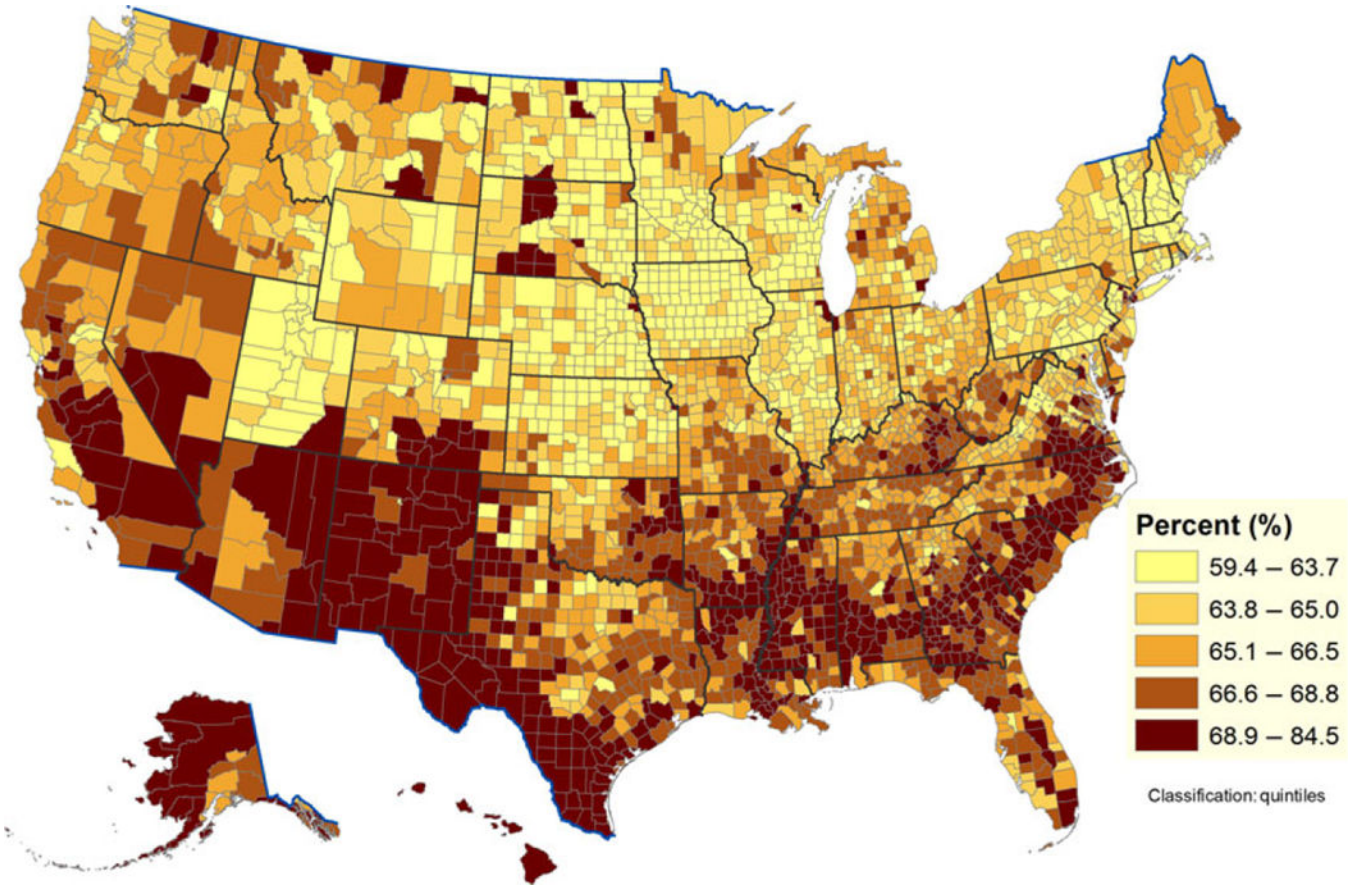

Fig. 4.

Model Estimated Prevalence of periodontitis in adults, ≥ 65 years of age, in US counties, 2009–2012. Data sources: CDC NHANES 2009–2012, Behavioral Risk Factor Surveillance System 2012, Census 2010, ACS 2007–2011.

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Table 1.

Characteristics of Older Adults with Periodontal Examinations (≥ 65 years of age), stratified according to age group [National Health and Nutrition Examination Study (NHANES) 2009–2012) (*n* = 1,511]

Characteristic	Age group		
	65–74 years (*n* = 897)	**75+ years (*n* = 614)**	**Total (≥ 65 years) (*n* = 1,511)**
Age, years	68.8 ± 0.1	78.7 ± 0.1 ***	72.5 ± 0.2
Male sex	48.8 (1.8)	43.4 (2.1)	46.8 (1.2)
Smoking status			
Never smokers	49.7 (2.3)	55.8 (2.5)	52.0 (1.5)
Former smokers	40.9 (2.5)	40.9 (2.5)	40.9 (1.8)
Current smokers	9.4 (1.3)	3.3 (0.6) ***	7.1 (0.9)
Income categories 1			
< 100% federal poverty level	7.0 (1.0)	9.5 (1.7)	7.9 (1.0)
100–199% Federal Poverty Level	19.2 (2.2)	26.0 (1.7) *	21.7 (1.6)
200–399% Federal Poverty Level	31.8 (2.6)	38.3 (2.5) *	34.2 (2.2)
≥ 400% Federal Poverty Level	42.1 (2.3)	26.2 (2.7) ***	36.2 (2.0)
Income categories 2			
Low (≤ 130% Federal Poverty Level)	13.9 (1.4)	18.7 (2.1) *	15.7 (1.3)
Middle (131–350% Federal Poverty Level)	39.4 (2.6)	49.3 (2.2) **	43.1 (2.0)
High (≥ 351% Federal Poverty Level)	46.7 (2.4)	32.1 (2.7) ***	41.3 (2.0)
Body mass index			
< 25 kg/m^2	38.6 (2.6)	25.8 (2.1) ***	33.8 (1.8)
25–29.9 kg/m^2	34.6 (1.9)	38.7 (2.0)	36.1 (1.4)
≥ 30 kg/m^2	26.8 (2.1)	35.6 (1.7) **	30.1 (1.7)
Diabetes mellitus (self-reported)	20.3 (1.9)	17.8 (1.5)	19.3 (1.5)
Use of dental floss in past 7 days			
Yes	75.0 (2.2)	66.0 (2.3) **	71.6 (1.8)
No	25.0 (2.2)	34.0 (2.3) **	28.4 (1.8)

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Characteristic	Age group		
	65–74 years (*n* = 897)	75+ years (*n* = 614)	Total (≥ 65 years) (*n* = 1,511)
Last dental visit[†]			
Within 6 months	63.8 (2.5)	63.0 (2.8)	63.5 (1.8)
6–12 months	12.5 (1.7)	9.9 (1.9)	11.6 (1.2)
> 12 months or never	23.7 (1.9)	27.1 (2.0)	24.9 (1.5)
No. of natural teeth	22.0 ± 0.2	19.8 ± 0.4***	21.2 ± 0.2
Dental implants			
Prevalence	5.1 (1.2)	4.0 (1.1)	4.7 (0.8)
Mean number/person	0.13 ± 0.03	0.12 ± 0.04	0.13 ± 0.03

Values are given as mean ± standard error or % (standard error).

Test for two age-group differences:

*$P < 0.05$,

**$P < 0.01$ and

***$P < 0.001$.

†Last dental-visit data based only on data from NHANES 2011–2012.

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Table 2.

Periodontal measures (mean, prevalence and extent in sites and in teeth) in dentate older adults (≥ 65 years of age), stratified according to age group [National Health and Nutrition Examination Study (NHANES) 2009–2012] (*n* = 1,511)

Clinical periodontal measure	Age group		
	65–74 years (*n* = 897)	75+ years (*n* = 614)	Total (65+ years) (*n* = 1,511)
Clinical attachment loss			
Mean clinical attachment level (mm)	1.74 ± 0.06	1.67 ± 0.07	1.71 ± 0.06
Prevalence of clinical attachment level of ≥ 3 mm	95.3 (1.0)	98.4 (0.7)*	96.4 (0.7)
Prevalence of clinical attachment level of ≥ 5 mm	57.7 (2.3)	69.9 (2.4)**	62.3 (1.7)
Proportion of sites with clinical attachment level of ≥ 3 mm/person	26.6 (1.3)	34.8 (1.9)***	29.7 (1.4)
Proportion of sites with clinical attachment level of ≥ 5 mm/person	8.1 (0.8)	9.9 (0.7)**	8.8 (0.7)
Proportion of teeth with clinical attachment level of ≥ 3 mm/person	48.7 (1.5)	59.0 (1.8)***	52.6 (1.4)
Proportion of teeth with clinical attachment level of ≥ 5 mm/person	16.2 (1.1)	20.9 (1.2)***	18.0 (1.0)
Periodontal probing depth			
Mean periodontal probing depth (mm)	1.64 ± 0.04	1.60 ± 0.03	1.63 ± 0.03
Prevalence of periodontal probing depth of ≥ 4 mm	50.5 (3.7)	44.7 (2.7)	48.3 (2.4)
Prevalence of periodontal probing depth of ≥ 6 mm	12.8 (1.8)	10.4 (1.7)	11.9 (1.4)
Proportion of sites with periodontal probing depth of ≥ 4 mm/person	3.8 (0.4)	2.8 (0.3)*	3.4 (0.3)
Proportion of sites with periodontal probing depth of ≥ 6 mm/person	0.55 (0.1)	0.29 (0.06)*	0.45 (0.07)
Proportion of teeth with periodontal probing depth of ≥ 4 mm/person	11.5 (1.0)	9.4 (0.8)	10.7 (0.7)
Proportion of teeth with periodontal probing depth of ≥ 6 mm/person	1.83 (0.29)	1.26 (0.26)	1.62 (0.22)

Values are given as mean ± standard error or % (standard error).

Prevalence differences were tested using the Chi-square test, and proportion and mean differences were tested using the *t*-test.

Test for difference between the two age groups:

* $P < 0.05$,

** $P < 0.01$ and

*** $P < 0.001$.

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Table 3.

Distribution of periodontitis, defined in accordance with the Centers for Disease Control and Prevention/American Academy of Periodontology (34) case definitions for dentate older adults (≥ 65 years of age), stratified according to age and sex [National Health and Nutrition Examination Study (NHANES) 2009–2012] (n = 1,511)

Periodontitis category	Age group					
	65–74 years		75+ years		Total (65+ years)	
	Male (n = 453)	Female (n = 444)	Male (n = 313)	Female (n = 301)	Male (n = 766)	Female (n = 745)
No periodontitis	22.9 (3.7)	33.9 (2.8) **	13.9 (3.2)	23.0 (3.6) *	19.8 (2.8)	29.5 (2.7) **
Nonsevere periodontitis (mild/moderate)	58.8 (4.7)	60.5 (2.7)	74.0 (3.1)	69.4 (3.4)	64.1 (3.3)	64.1 (2.5)
Severe periodontitis	18.3 (2.5)	5.6 (1.3) ***	12.1 (2.5)	7.6 (1.4)	16.2 (2.2)	6.4 (1.1) ***

Data are given as % (standard error) (n = 1,511).

Chi-square significance test for differences between the sexes within each age group:

* $P < 0.05$,

** $P < 0.01$ and

*** $P < 0.001$.

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Table 4.

Prevalence of severe and nonsevere (mild and moderate) periodontitis, defined in accordance with the Centers for Disease Control and Prevention/ American Academy of Periodontology (34) case definitions for dentate older adults (≥ 65 years of age), stratified according to demographic and health-related subgroups [National Health and Nutrition Examination Study (NHANES) 2009–2012]

Subgroup	Severe periodontitis	Nonsevere periodontitis	Total (severe + nonsevere) periodontitis
All ≥ 65 years	11.0 (1.4)	57.0 (2.2)	68.0 (2.2)
Age group			
65–74 years	11.8 (1.7)	59.7 (3.1)	71.5 (2.6)
≥ 75 years	9.6 (1.4)	71.4 (2.4)	81.0 (2.3)
Sex			
Male	16.2 (2.2)	64.1 (3.3)	80.2 (2.8)
Female	6.4 (1.1)	64.1 (2.5)	70.5 (2.7)
Smoking status			
Never smokers	9.1 (1.3)	64.1 (2.4)	73.2 (2.3)
Former smokers	9.9 (1.7)	64.4 (2.7)	74.3 (2.8)
Current smokers	30.9 (7.2)	61.8 (8.0)	92.6 (4.2)
Income categories 1			
< 100% Federal Poverty Level	14.7 (1.6)	60.8 (4.1)	75.6 (3.5)
100–199% Federal Poverty Level	15.9 (2.5)	60.4 (3.2)	76.3 (2.9)
200–399% Federal Poverty Level	10.7 (2.3)	69.0 (3.5)	79.7 (3.5)
≥ 400% Federal Poverty Level	8.3 (1.9)	62.4 (3.4)	70.7 (3.2)
Income categories 2			
Low (≤ 130% Federal Poverty Level)	17.7 (2.2)	61.8 (2.9)	79.5 (2.5)
Middle (131–350% Federal Poverty Level)	11.9 (2.0)	65.9 (2.8)	77.8 (2.8)
High (≥ 351% Federal Poverty Level)	8.2 (1.7)	62.8 (3.4)	71.0 (3.2)
Body mass index			
< 25 kg/m^2	11.2 (2.5)	63.3 (3.0)	74.5 (3.0)
25–29.9 kg/m^2	10.2 (1.8)	64.5 (3.3)	74.7 (2.7)
≥ 30 kg/m^2	11.4 (2.3)	64.6 (3.2)	76.0 (3.3)
Diabetes mellitus			

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Subgroup	Severe periodontitis	Nonsevere periodontitis	Total (severe + nonsevere) periodontitis
Yes	10.8 (2.9)	72.4 (4.2)	83.1 (3.3)
No	11.0 (1.5)	62.1 (2.5)	73.1 (2.3)
Use of dental floss in past 7 days			
Yes	9.7 (1.4)	64.3 (2.9)	74.0 (2.6)
No	13.8 (2.4)	63.0 (3.4)	76.8 (3.3)
Last dental visit *			
Within 6 months	21.2 (4.7)	56.4 (6.6)	77.6 (4.6)
6–12 months	10.6 (4.6)	56.9 (6.9)	67.5 (9.4)
> 12 months or never	6.7 (1.9)	54.5 (5.1)	61.2 (4.3)

Data are given as % (standard error) (n = 1,511).

* Last dental visit data based only on data from NHANES 2011–2012.

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Table 5.

Summary of estimated prevalence of severe and total (severe + nonsevere) periodontitis in older adults (≥ 65 years of age), stratified according to States (and District of Columbia) and to local areas in the USA, 2009–2012*

	Number of geographic units	Minimum (%)	Quartile 1 (%)	Median (%)	Quartile 3 (%)	Maximum (%)	Mean (%)	Range (maximum minus minimum) (per-centage points)
Total periodontitis (severe or nonsevere)								
States + District of Columbia	51	62.1	64.2	65.9	67.4	74.2	66.2	12.1
Congressional Districts	436	61.1	64.3	65.7	68.4	83.3	67.1	22.2
Counties	3,143	59.4	64.0	65.6	67.9	84.5	66.4	25.1
Census tracts	72,251	47.8	63.2	65.9	71.2	93.4	68.0	45.6
Severe periodontitis								
States + District of Columbia	51	9.5	10.8	11.8	12.6	16.3	11.8	6.8
Congressional Districts	436	9.0	10.8	11.6	13.1	21.4	12.3	12.4
Counties	3,143	8.5	10.6	11.4	12.7	24.0	11.9	15.5
Census tracts	72,251	4.2	10.2	11.4	14.2	41.8	12.8	37.6

* Data sources: National Health and Nutrition Examination Study (NHANES) 2009–2012; Behavioral Risk Factor Surveillance System 2012; Census 2010; and American Community Survey 2007–2011.

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Table 6.

Model estimated prevalence in older adults (≥ 65 years of age) of severe and total (severe + nonsevere) periodontitis, stratified according to State and the District of Columbia

State name	State name abbreviation	State Federal Information Processing Standard code*	Severe periodontitis	Total periodontitis
All 50 states and District of Columbia			11.0 (8.26–13.74)	68.0 (63.69–72.31)
Utah	UT	49	9.50 (9.34–9.69)	62.12 (61.72–62.55)
New Hampshire	NH	33	9.97 (9.73–10.21)	62.63 (62.11–63.13)
Vermont	VT	50	10.13 (9.81–10.46)	63.10 (62.38–63.83)
Iowa	IA	19	10.18 (10.03–10.33)	63.11 (62.77–63.43)
North Dakota	ND	38	10.37 (10.07–10.71)	63.36 (62.68–64.10)
Minnesota	MN	27	10.43 (10.31–10.55)	63.54 (63.29–63.81)
Nebraska	NE	31	10.61 (10.43–10.81)	63.85 (63.43–64.29)
Wisconsin	WI	55	10.65 (10.53–10.77)	63.86 (63.61–64.11)
Maine	ME	23	10.54 (10.30–10.79)	63.95 (63.43–64.50)
Connecticut	CT	9	10.77 (10.64–10.89)	63.96 (63.69–64.22)
Massachusetts	MA	25	10.70 (10.60–10.81)	63.96 (63.75–64.19)
Rhode Island	RI	44	10.76 (10.51–11.04)	64.09 (63.53–64.71)
South Dakota	SD	46	10.77 (10.49–11.08)	64.22 (63.56–64.91)
Kansas	KS	20	10.89 (10.73–11.05)	64.40 (64.05–64.75)
Wyoming	WY	56	10.85 (10.46–11.24)	64.42 (63.63–65.28)
Pennsylvania	PA	42	11.15 (11.08–11.23)	64.70 (64.54–64.87)
Idaho	ID	16	10.87 (10.60–11.14)	64.73 (64.11–65.35)
Oregon	OR	41	10.92 (10.76–11.10)	64.78 (64.40–65.15)
Washington	WA	53	10.96 (10.85–11.07)	64.80 (64.56–65.04)
Montana	MT	30	11.13 (10.83–11.46)	65.05 (64.44–65.70)
Ohio	OH	39	11.53 (11.45–11.61)	65.38 (65.21–65.55)
Indiana	IN	18	11.48 (11.36–11.59)	65.38 (65.11–65.62)
Colorado	CO	8	11.51 (11.39–11.64)	65.73 (65.46–65.99)
Delaware	DE	10	11.75 (11.47–12.04)	65.82 (65.23–66.45)

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State name	State name abbreviation	State Federal Information Processing Standard code*	Severe periodontitis	Total periodontitis
Michigan	MI	26	11.84 (11.75–11.93)	65.93 (65.75–66.13)
Missouri	MO	29	11.78 (11.65–11.90)	65.94 (65.69–66.21)
West Virginia	WV	54	11.64 (11.41–11.88)	65.99 (65.51–66.45)
New Jersey	NJ	34	11.76 (11.67–11.85)	66.05 (65.87–66.23)
Illinois	IL	17	11.87 (11.80–11.95)	66.15 (65.98–66.30)
Virginia	VA	51	11.85 (11.76–11.95)	66.17 (65.98–66.39)
Kentucky	KY	21	11.90 (11.77–12.04)	66.39 (66.12–66.69)
Maryland	MD	24	12.13 (12.03–12.24)	66.71 (66.51–66.92)
Arizona	AZ	4	12.10 (11.97–12.24)	66.78 (66.49–67.06)
Tennessee	TN	47	12.28 (12.14–12.41)	66.88 (66.60–67.14)
Oklahoma	OK	40	12.31 (12.17–12.47)	66.95 (66.66–67.26)
Arkansas	AR	5	12.33 (12.14–12.53)	67.05 (66.62–67.47)
North Carolina	NC	37	12.58 (12.49–12.69)	67.39 (67.19–67.59)
Alaska	AK	2	12.51 (12.18–12.87)	67.41 (66.86–68.04)
New York	NY	36	12.40 (12.34–12.46)	67.43 (67.31–67.55)
Alabama	AL	1	12.75 (12.62–12.88)	67.56 (67.29–67.85)
Florida	FL	12	12.64 (12.55–12.72)	67.9 0 (67.74–68.07)
South Carolina	SC	45	12.91 (12.77–13.06)	67.91 (67.63–68.21)
Georgia	GA	13	12.91 (12.81–13.02)	68.04 (67.82–68.25)
Nevada	NV	32	12.86 (12.71–13.03)	68.22 (67.88–68.56)
Louisiana	LA	22	13.51 (13.37–13.65)	68.77 (68.50–69.06)
California	CA	6	12.84 (12.79–12.88)	68.97 (68.89–69.06)
Mississippi	MS	28	13.67 (13.49–13.86)	69.18 (68.83–69.56)
Texas	TX	48	13.51 (13.44–13.57)	69.49 (69.37–69.61)
New Mexico	NM	35	14.65 (14.43–14.86)	71.64 (71.31–72.00)
Hawaii	HI	15	14.42 (14.12–14.75)	73.00 (72.56–73.42)
District of Columbia	DC	11	16.28 (15.88–16.71)	74.24 (73.71–74.86)

Values are given as mean % (95% confidence interval) (n = 1,511).

*https://www.census.gov/geo/reference/ansi_statetables.html.